TOPEX, Jason-1, and GRACE: Missions that Study Our Earth

Jet Propulsion Laboratory
- Earth is a water planet -- 70% is water
- The interaction of ocean and atmosphere drive weather patterns and control climate change.
• **Climate Research:** By modeling changes in the distribution of heat in the ocean with TOPEX/POSEIDON & Jason-1 data, scientists can study patterns of evaporation and resultant precipitation in the ocean system.

• **Ship Routing:** Maps of currents and eddies from TOPEX/POSEIDON and Jason-1 are used in commercial shipping and recreational yachting to optimize routes.

• **Offshore Industries:** Cable-laying vessels and offshore oil operations require accurate knowledge of ocean circulation patterns to minimize impacts from strong currents.

• **Hurricane Forecasting:** Altimeter data are incorporated into atmospheric models for hurricane season forecasting and individual storm severity.

• **Fisheries Management:** Altimeter data identifies ocean eddies which bring an increase in organisms that comprise the marine food web, attracting fish and fishermen.

• **Marine Mammal Research:** Sperm whales, fur seals, and other marine mammals are tracked, and therefore studied, around ocean eddies where nutrients and plankton are abundant.

• **El Niño & La Niña Forecasting:** Understanding the pattern and effects of climate cycles such as the El Niño Southern Oscillation (ENSO) is a primary goal of the TOPEX/POSEIDON and Jason-1 missions.

• **Coral Reef Research:** Altimeter data is used to monitor and assess coral reef ecosystems, which are sensitive to changes in ocean temperature due to large-scale climate variability.

• **Ocean Debris Tracking:** Altimeter data can be used to calculate ocean currents to identify likely locations of marine debris which can pose a hazard to coral reefs, marine mammals, and oceangoing vessels.

• **Snow Pack & Polar Ice Sheet Studies:** Glacial flow monitoring; seasonal snow pack variation
TOPEX/Poseidon
Launched: August 10, 1992

TOPEX/Poseidon
• Measure sea level with accuracy <5 centimeters
• Provide a 3-year global view of the global ocean topography
• Increase understanding of ocean circulation
• Improve forecasting of global climate
• Improve knowledge of Earth’s gravity field

• 3 year Prime mission; Extended mission to 6 years
• 10-day repeat of ground track (±1 km accuracy)
• Covers 95% of ice-free oceans every 10-days
• Global data coverage between 66°N and 66°S latitude
• Orbital altitude of 1336 km, circular, 66° inclination
• Has provided unprecedented data set for 9 years!
Jason-1
Launched: December 7, 2001

- Follow on to TOPEX/Poseidon (T/P)
- Extend ocean topography measurements for understanding and predicting climate change with sea level measurement accuracy <4.2 centimeters
- Provide a 5-year global view of the global ocean topography
- Increase understanding of ocean circulation and seasonal changes
- Improve forecasting of events such as El Niño
- Measure global sea-level change

- Beginning of operational satellite altimetry
- 18-day repeat of ground track (±1 km accuracy)
- Covers 95% of ice-free oceans every 10-days
- Global data coverage between 66°N and 66°S latitude
- Orbital altitude of 1336 km, circular, 66° inclination
- Data available through Physical Oceanography Distributed Active Archive Center and AVISO (French)
The Gravity Recovery and Climate Experiment (GRACE) is twin satellites that will be used to map Earth’s gravity field.

Variations that GRACE will measure include changes due to ocean circulation, groundwater storage, polar ice, and variations of mass within the Earth.

**Mission**
- 5-year mission
- International partner: Germany

**Science**
- New model of the Earth’s gravity field every 30 days
- Enables monitoring of ocean heat transport
- Potential to track the storage of water in the Hydrologic Cycle
Global mean sea level variation diagram

Global sea level has increased at an average rate (red line) of 2.4 millimeters per year from 1993-2001.

Rate ≈ 2.4 mm/year

Nerem, 2001
SPACECRAFT COMPARISON

TOPEX/Poseidon
2500 kg

Jason-1
500 kg
JASON-1 Remote Sensing Technique

JASON-1 MEASUREMENT SYSTEM

GPS SATELLITE

MICROWAVE MEASUREMENT OF COLUMNAR WATER VAPOR

RADAR ALTIMETER RANGING

DORIS BEACON

LASER RANGING STATION

OCEAN TOPOGRAPHY

SEA SURFACE

SEA LEVEL

SEA-FLOOR TOPOGRAPHY

REFERENCE ELLIPSOID
Deep Ocean Circulation and Heat Transport
- Measure Spacecraft to Spacecraft distance to a few millionths of an inch

- Requires extremely sensitive instruments (star camera, accelerometer)
GRACE Applications

GRACE Sensitive to 1 cm change in large US Aquifer depths
GRACE Remote Sensing of the Atmosphere (Radio Occultation)
CHAMP GPS Occultation Experiment
First Temperature Profile (11/02/01)
19:33 UTC Lat: -80.37 Lon: 80.04

GFZ Potsdam

Temperature [°C]
Because, it's clear that Earth is an ocean planet.

"Climate touches all of us. On a longer time scale, probably the most important determinant of human civilization has been climate."

Dr. William Patzert, NASA/JPL Oceanographer
JPL’s Earth Science Program
http://www.jpl.nasa.gov/earth

JPL’s Altimetry Missions
http://sealevel.jpl.nasa.gov

CNES’s Altimetry Missions

GRACE Mission Home Page
http://www.csr.utexas.edu/grace

CHAMP Mission Home Page
http://op.gfz-potsdam.de/champ

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JPL missions provide a wealth of information for studying long-term climate, improving weather prediction, and determining the impact of humans on the environment.
GRACE Spacecraft
• Climate Research
• Ship Routing
• Offshore Industries
• Hurricane Forecasting
• Fisheries Management
• Marine Mammals Research
• El Niño & La Niña Forecasting
• Coral Reef Research
• Ocean Debris Tracking
Monitoring El Niño and La Niña

- NOAA long term climate forecasts: flood control, agricultural strategy, water and energy use planning
- Media use to explain weather and climate to the public
- TOPEX/POSEIDON data have become familiar to more than a billion people worldwide

Images produced by Dr. Victor Zlotnicki, Dr. Lee -Lueng Fu and Akiko Hayashi, of the Oceans Research Element at NASA’s Jet Propulsion Laboratory.
Long-term seasonal forecasts of the numbers and strengths of hurricanes expected in a given hurricane season

Short term forecasts of the strength of individual hurricanes
Private companies make charts of surface height.

Eddies and swift moving currents can be identified.

Transatlantic ship routing, cable laying, and oil exploration use these maps to increase safety and economic return.
- TOPEX/POSEIDON altimeter sea level and NOAA AVHRR sea surface temperature data monitor and assess global coral reef environments.

- High and low tropical sea levels and ocean temperatures caused by the '97 to '98 El Niño/La Niña “bleached” 25% of all coral reefs.
Jason-1 and its successors will enable critical topographic measurements to continue without interruption, giving us the time scales needed to observe global climate changes.
TOPEX Data Products
Joint Mission with French Space Agency (CNES)
- CNES provided satellite; NASA provided launch vehicle;
  Mission Operations at JPL
Follow-on to TOPEX/POSEIDON, Same Circular 1336 km, 66
degree inclination orbit.
Launch Vehicle: Boeing Delta II 7920
Launch Site: Vandenberg AFB, California
Dual Launch: Shared with TIMED, another NASA mission
  - Jason-1 will separate first
Five Instruments:
- Altimeter - measures sea level (CNES)
- Radiometer - Measures water vapor (JPL)
- DORIS - Satellite tracking (CNES)
- TRSR - Global Positioning System Receiver (JPL)
- LRA - Laser Satellite Positioning (JPL)
Satellite Mass: 500 kg
Satellite platform: Proteus spacecraft bus